TESTS IN HELIUM ILLUSTRATE HIGH MACH NUMBER INLET - FOREBODY INTERACTIONS

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HIGH-SPEED INLET-FOREBODY INTERACTIONS TESTS

(A Propulsion Perspective)

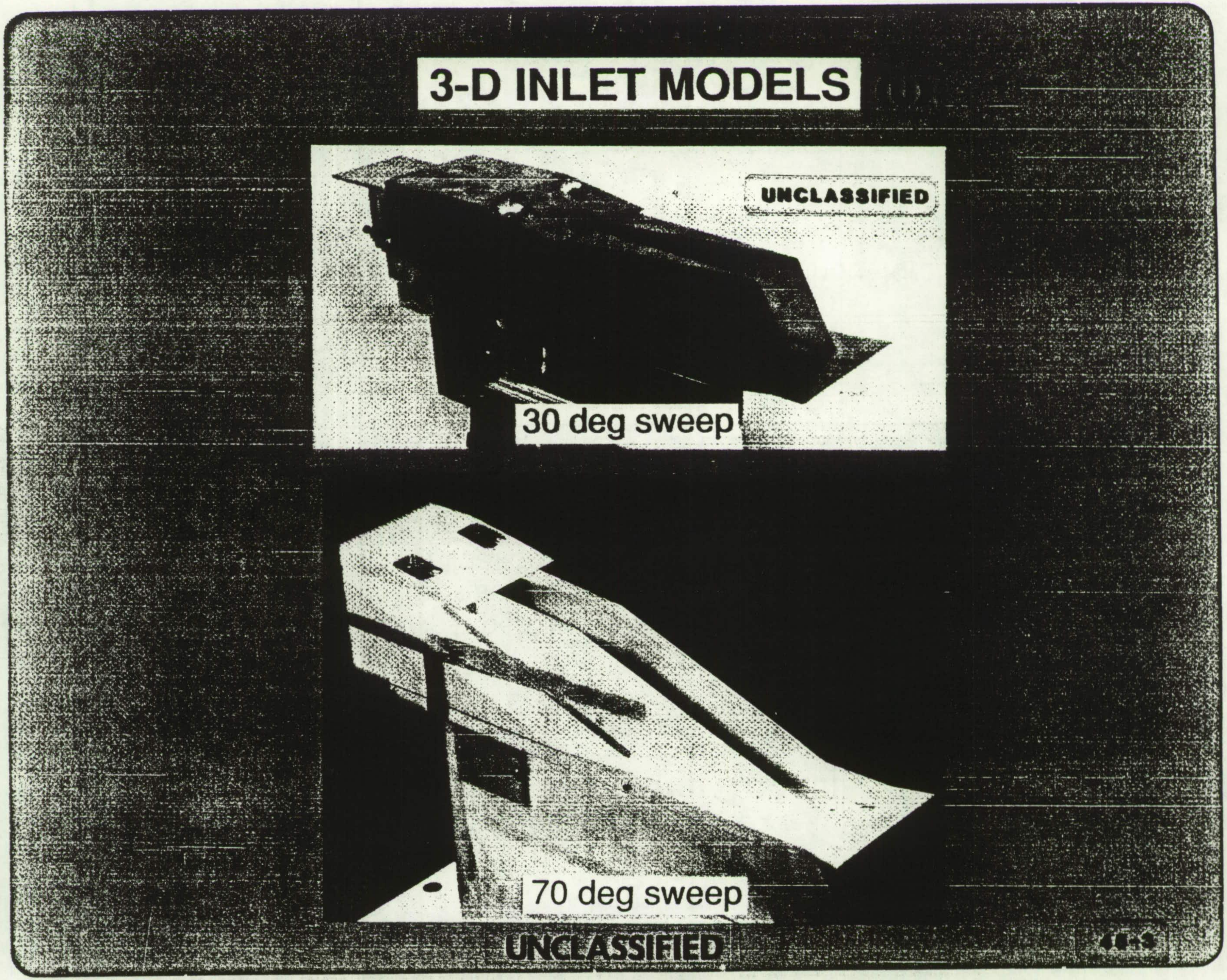
Objectives:

- Identify the impact of the forebody flow on inlet performance and operability
  - Interaction of thick forebody boundary layer with inlet geometry and compressive shock waves; addressed in current tests
  - Influence of flow uniformity and resulting lateral boundary layer concentrations; not addressed in current tests
- Calibrate/develop CFD codes to allow analysis for other geometries and conditions

HIGH MACH HELIUM TESTS
Langley Mach 18 60" Helium Tunnel

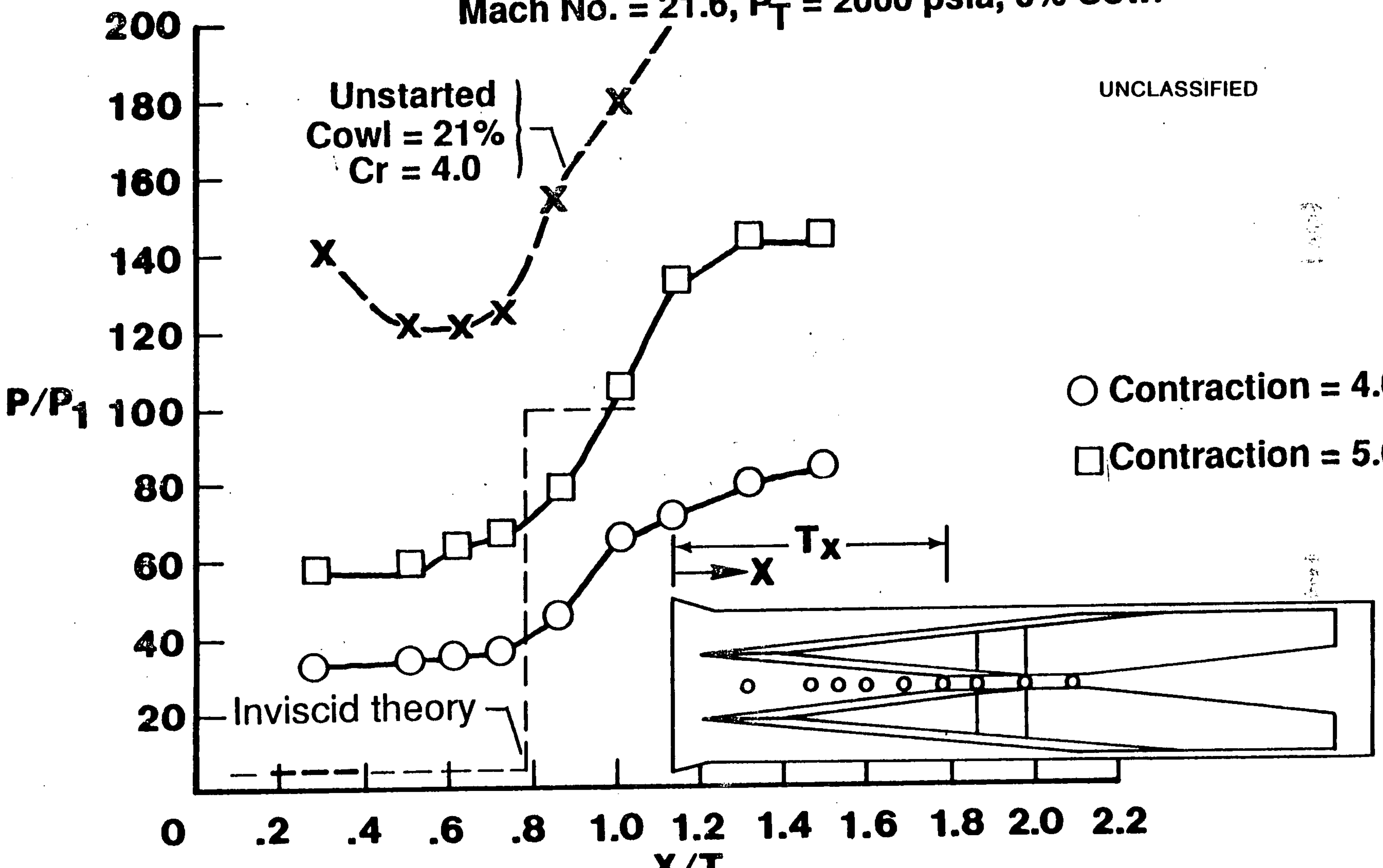
- Why Helium?
  - Ambient total temperature, inexpensive models
  - Large forebody and high Reynolds number match flight conditions
  - Perfect gas, ideal for CFD validation
  - Studies of fundamental shock/viscous interactions to establish performance and operability characteristics. (note: actual inlet configurations cannot be tested due to high value of the ratio of specific heat).

- Helium Test Program
  - Existing sidewall compression inlet models with and without forebody
  - Planned parametric sidewall compression inlet test
  - Parametric 2-D inlet with sidewalls


3-D INLET MODELS
UNCLASSIFIED
30 deg sweep
70 deg sweep
UNCLASSIFIED

30° SWEPT INLET (U)

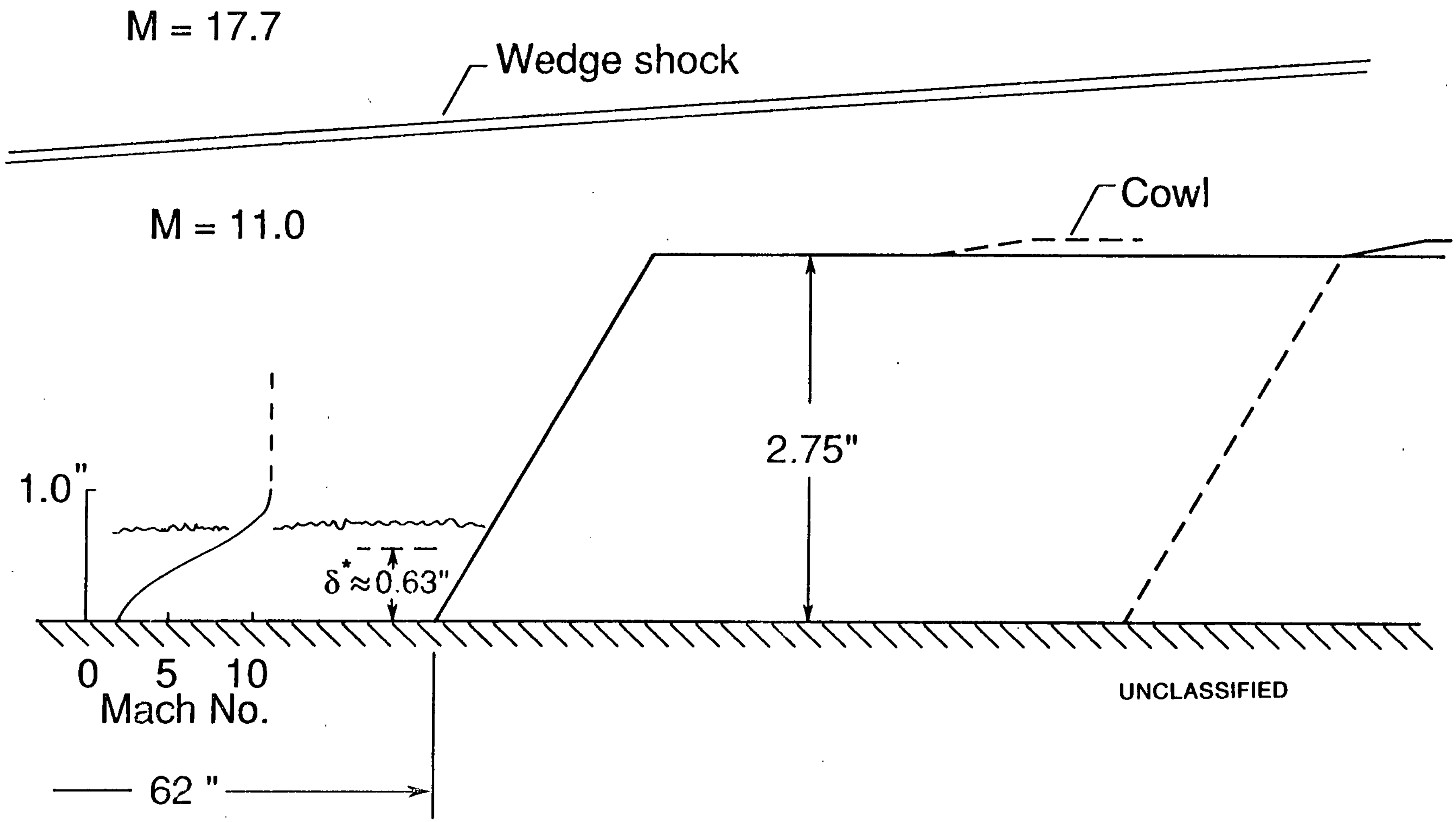
Mach No. = 21.6, P_T = 2000 psia, 0% Cowl



45-4

UNCLASSIFIED

BOUNDARY LAYER APPROACHING INLET (U)



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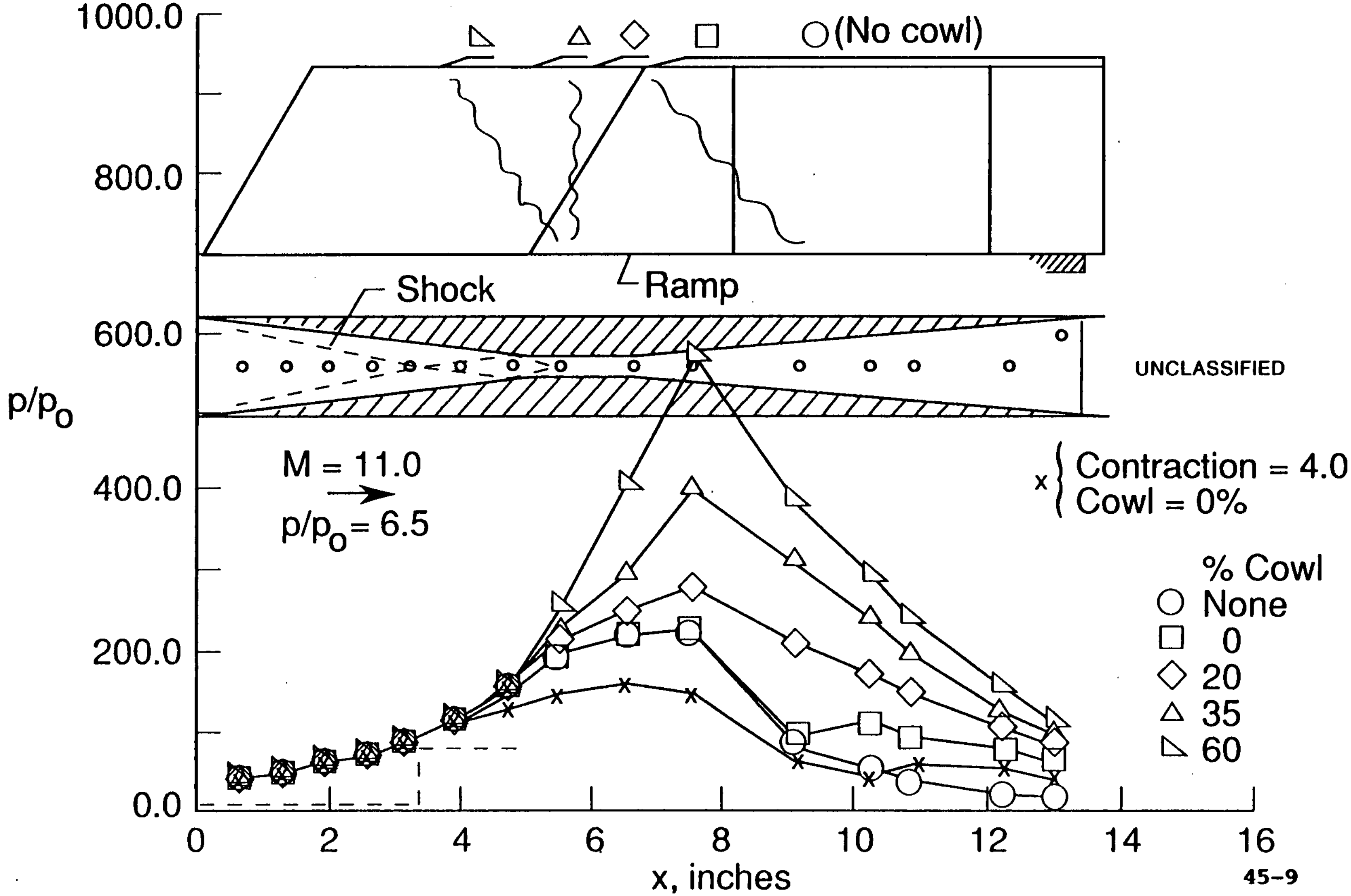
UNCLASSIFIED

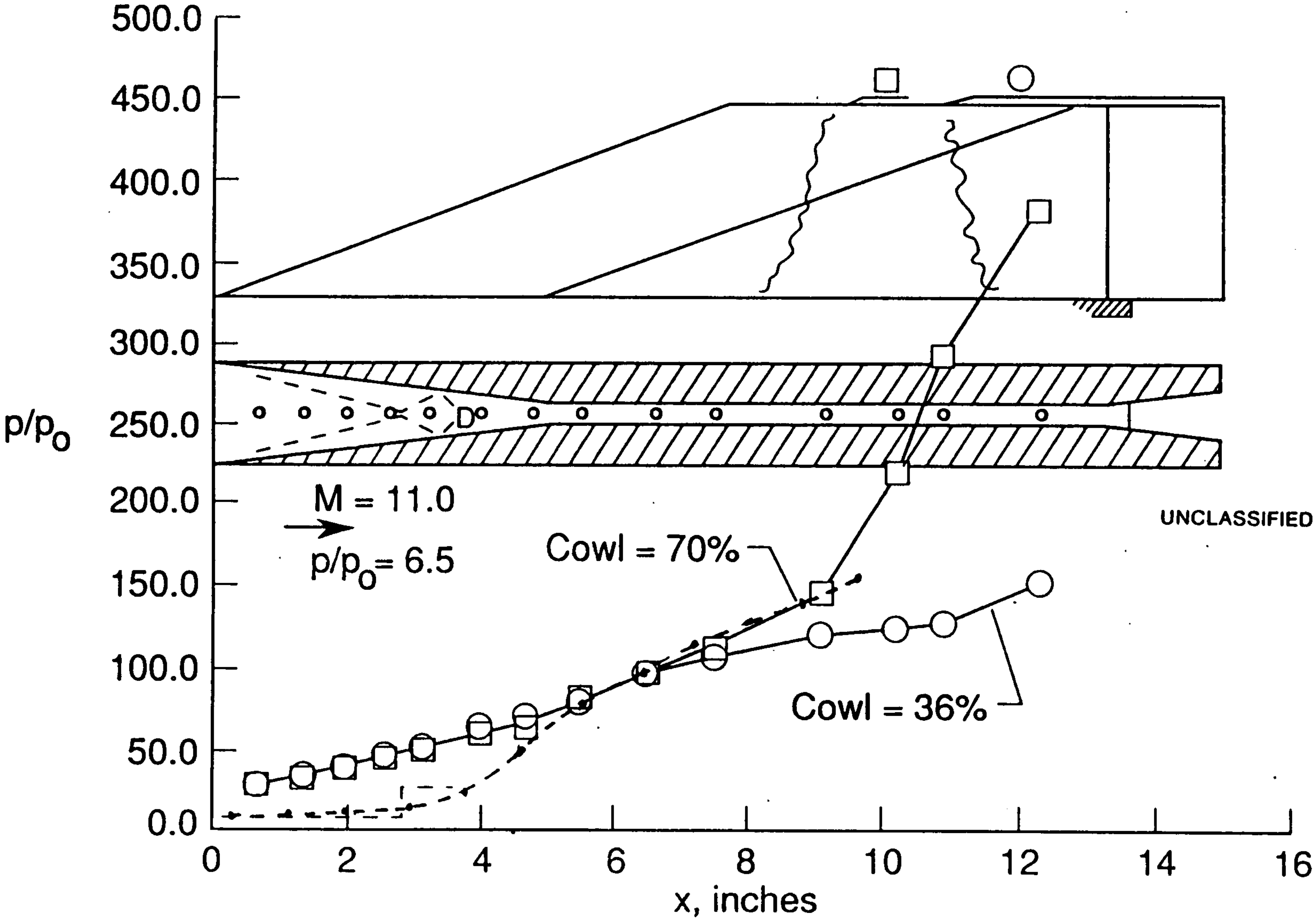
RAMP SURFACE PRESSURE DISTRIBUTION (U)

30° Sweep inlet mounted on 4° wedge foreplate
Mach No. = 18, P_T = 1200 psia, Cr = 5.0



RAMP SURFACE PRESSURE DISTRIBUTION (U)

70° Sweep inlet mounted on 4° wedge foreplate
Mach No. = 18, P_T = 1200 psia, Cr = 5.0



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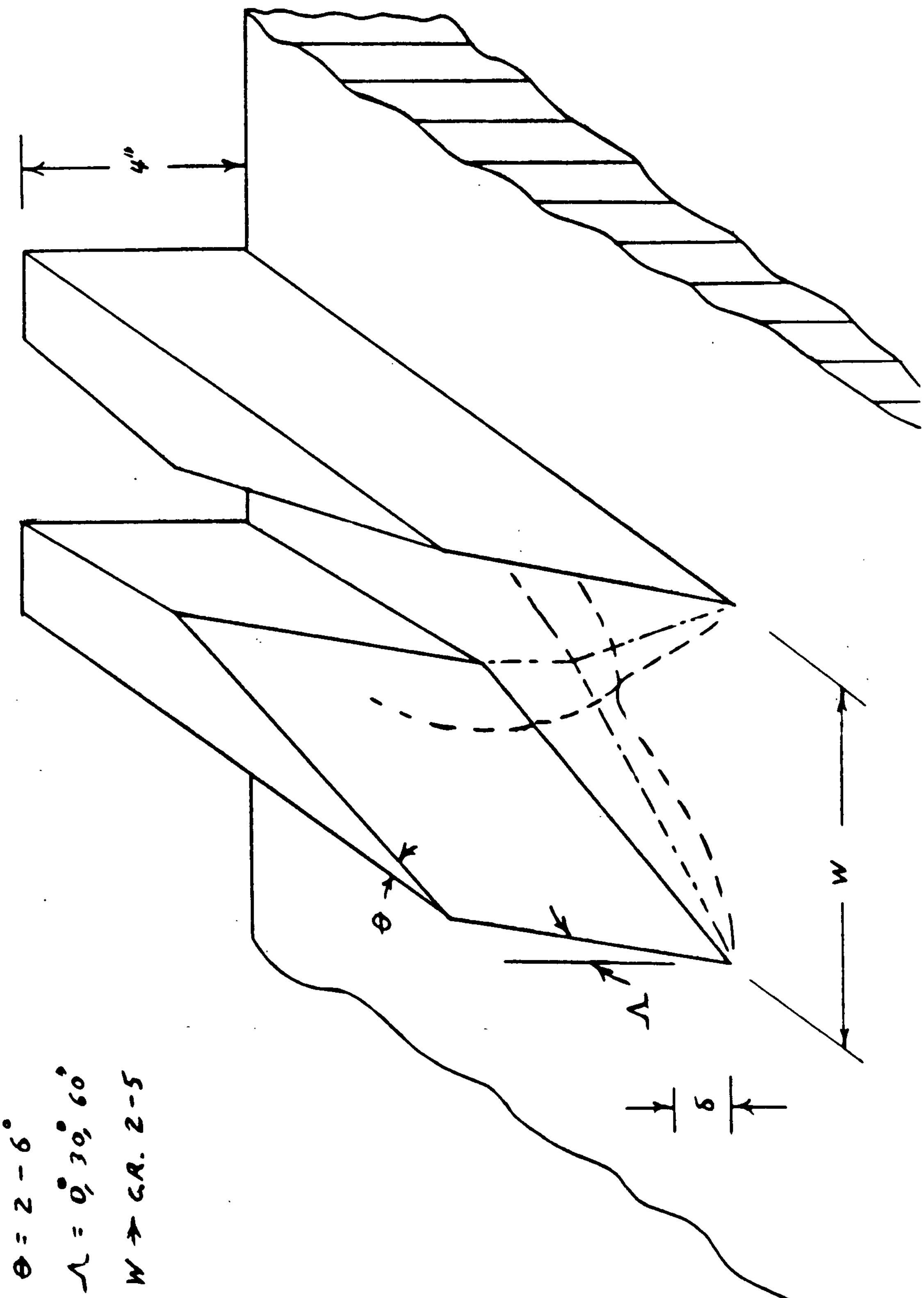
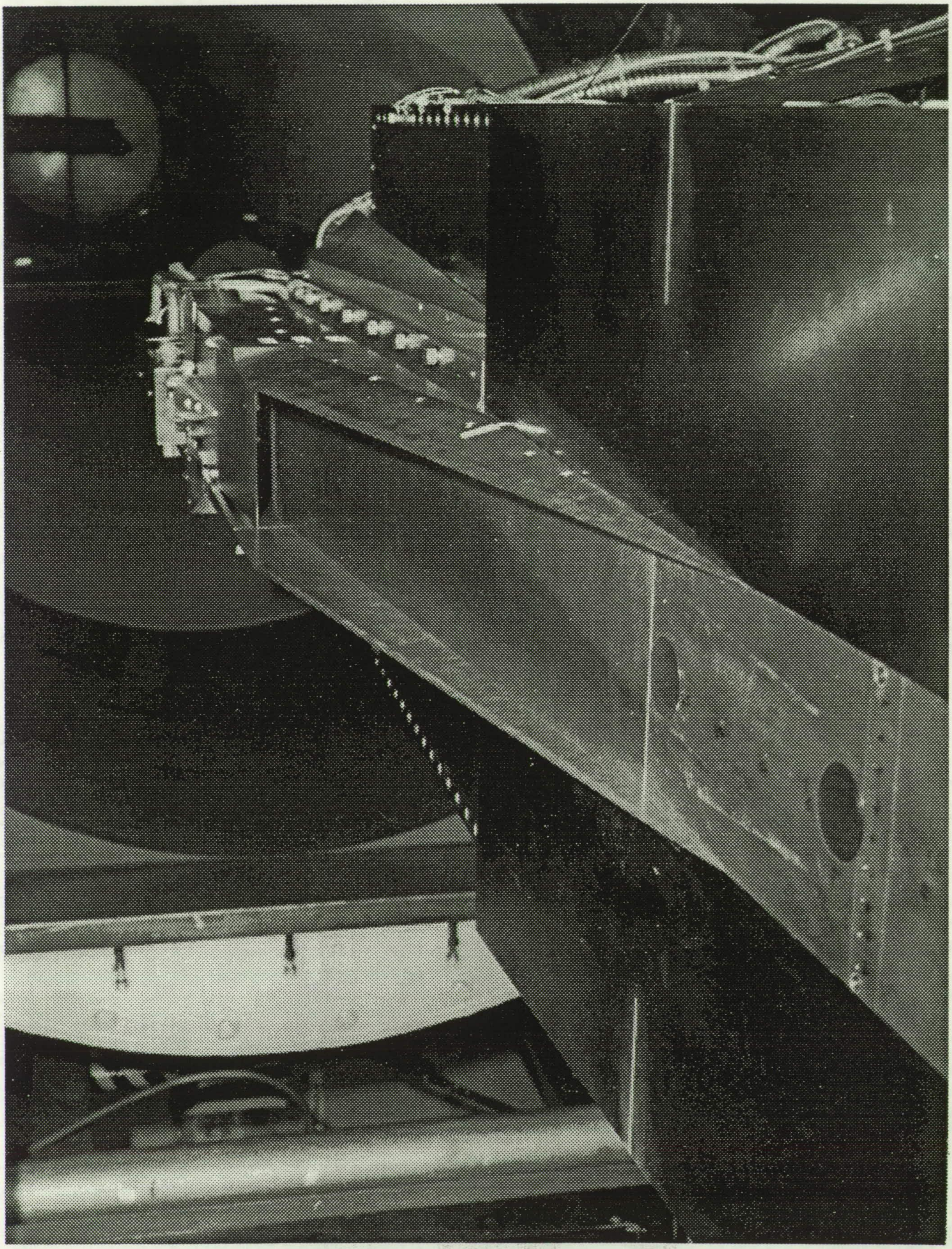
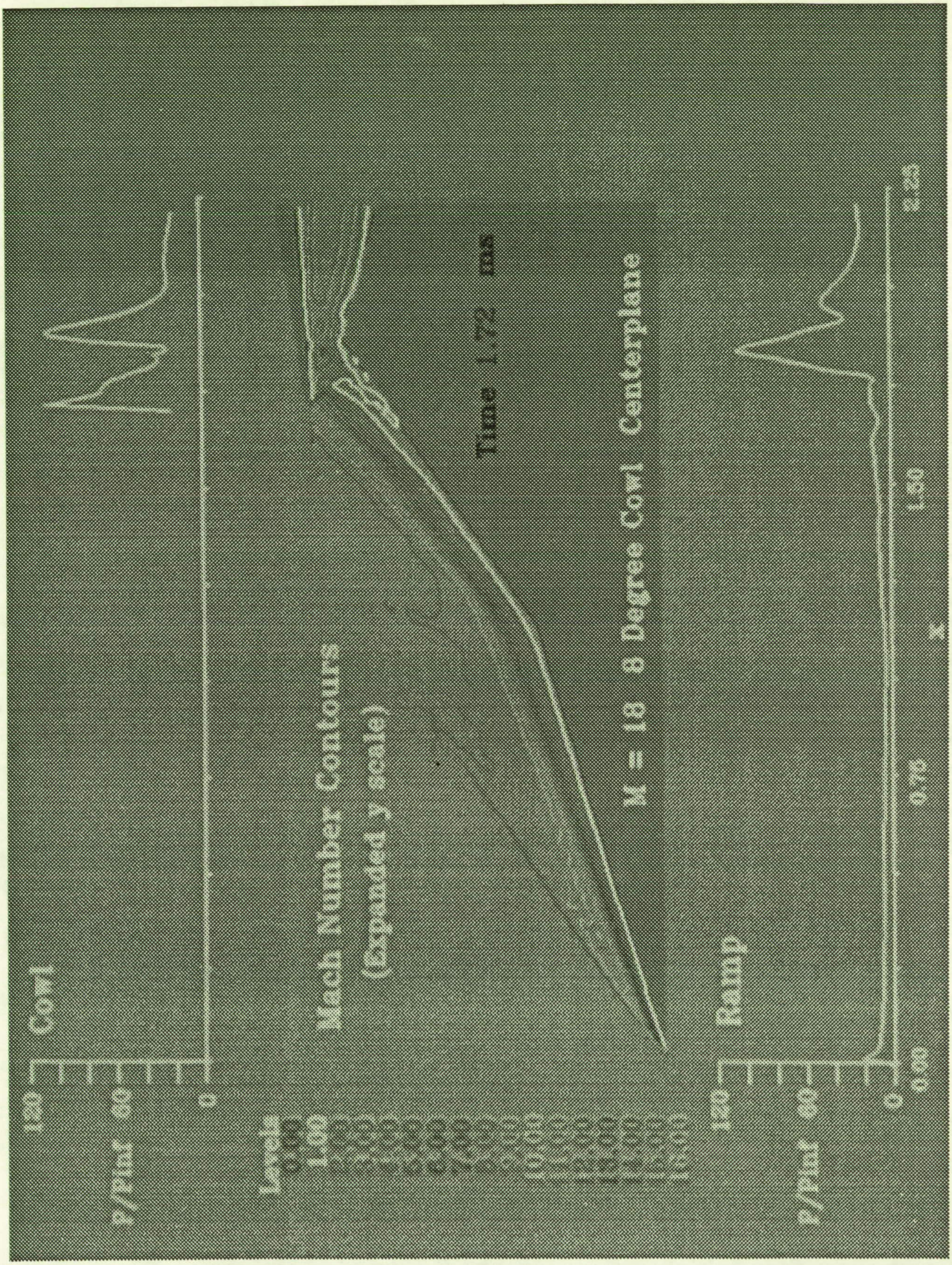

4"
θ
Λ
W
δ
θ = 2 - 6°
Λ = 0°, 30°, 60°
W → GR. 2-5

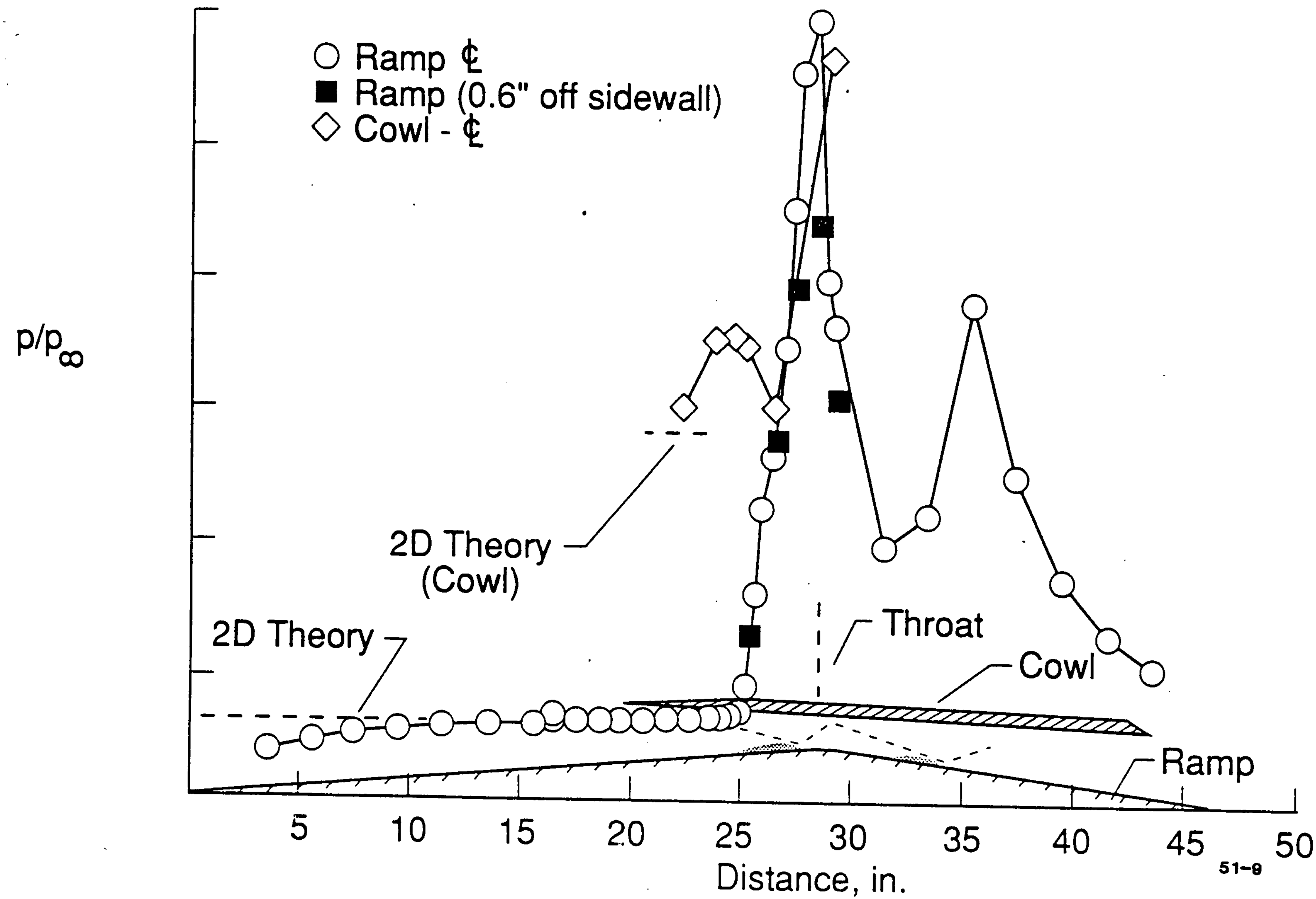




ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH

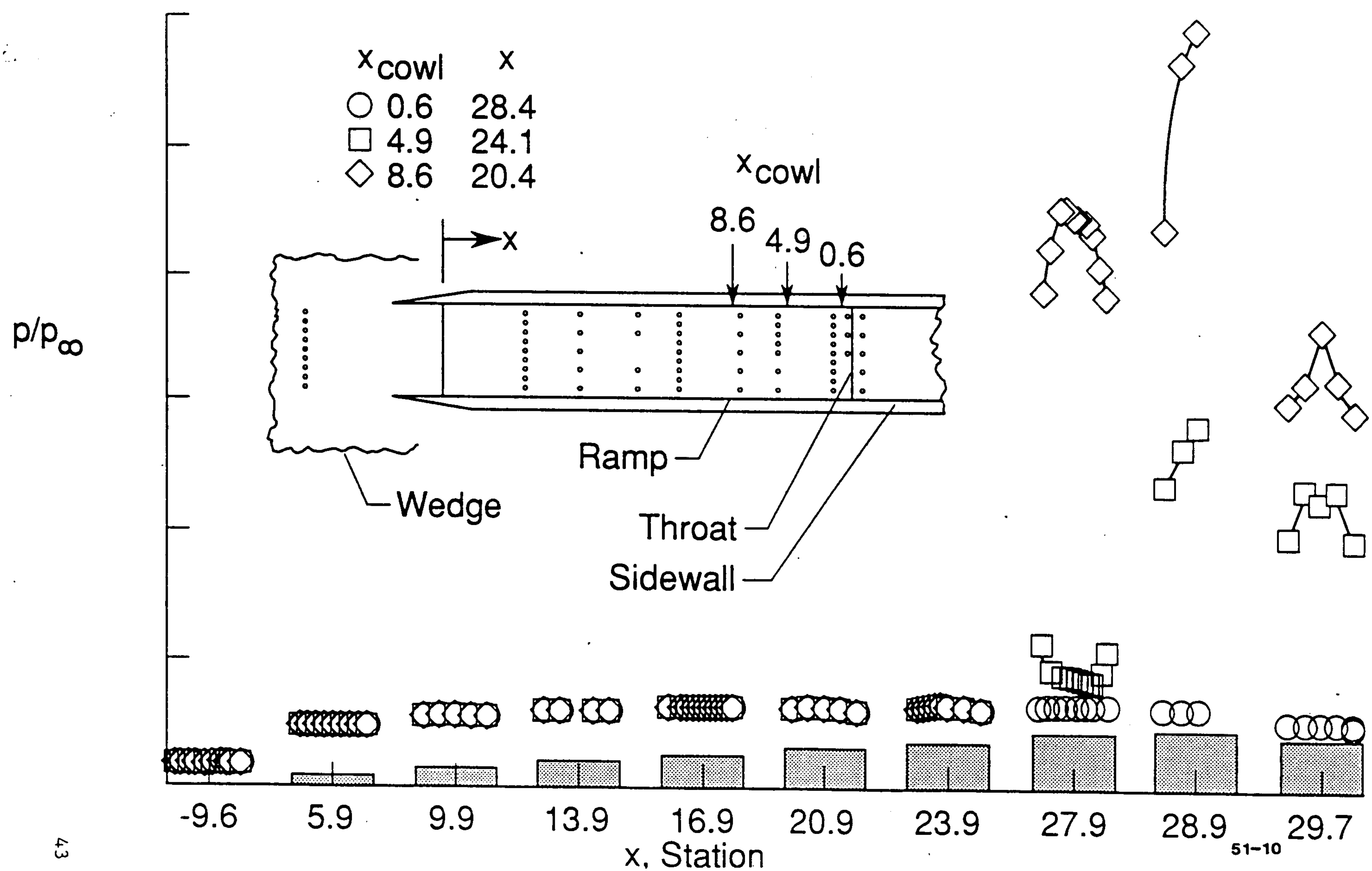
STATIC PRESSURE ON RAMP AND 8^{O} COWL (U)

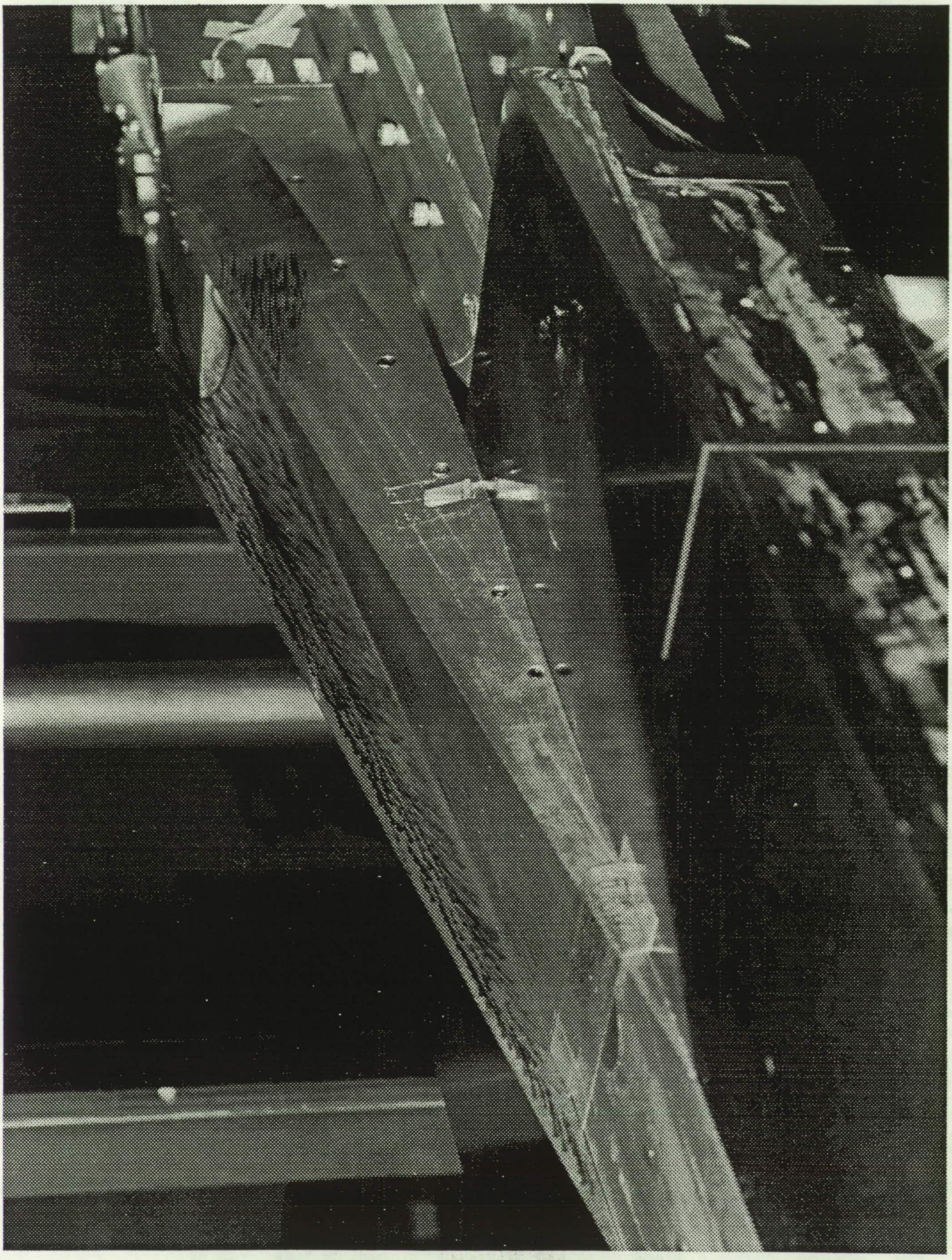
Mach 18, P_T = 1200 psia, X_{cowl} = 8.6"



PRESSURE VARIATION ACROSS WEDGE AND RAMP (U)

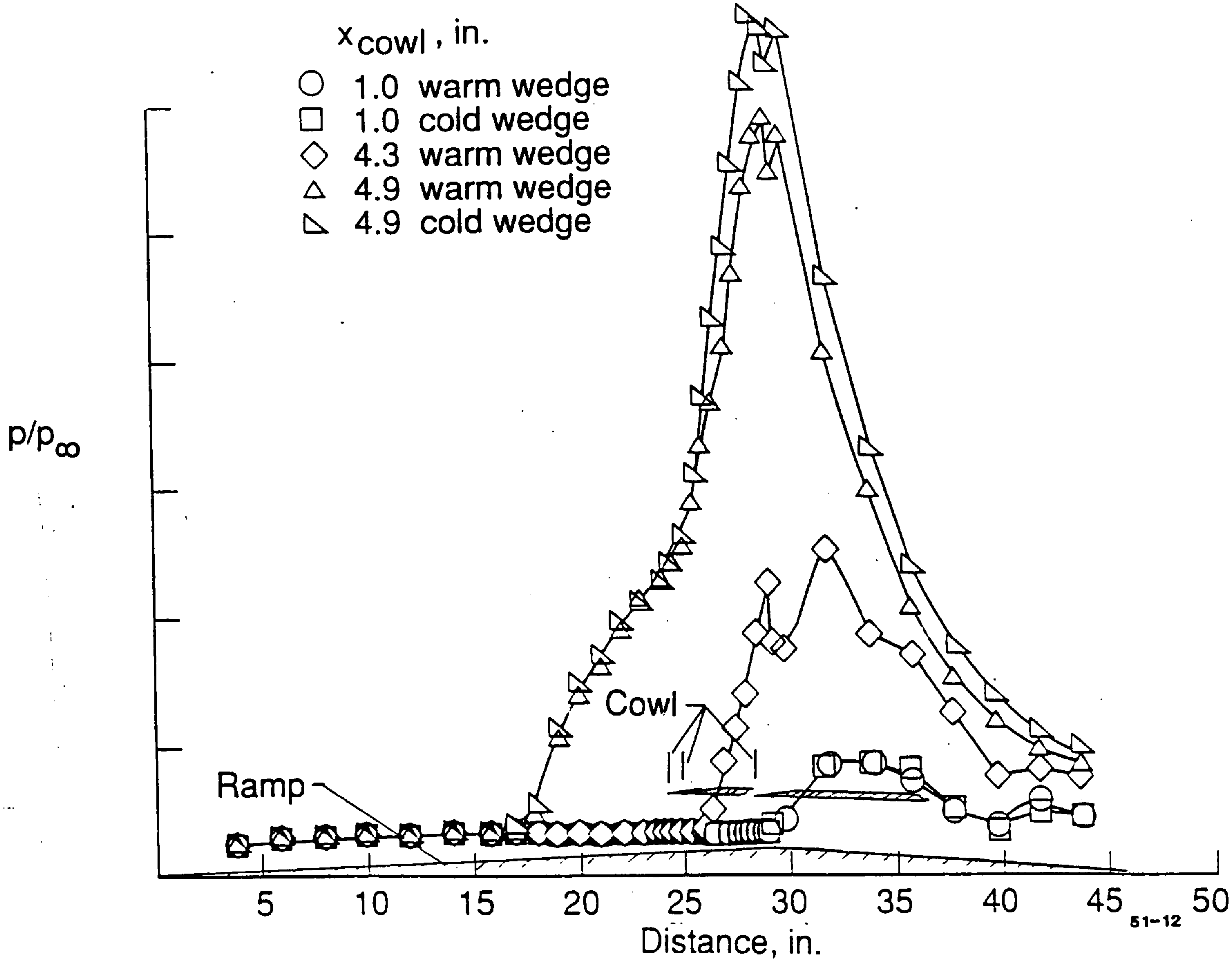
Mach 18, P_T = 1200 psia, 8^oCowl



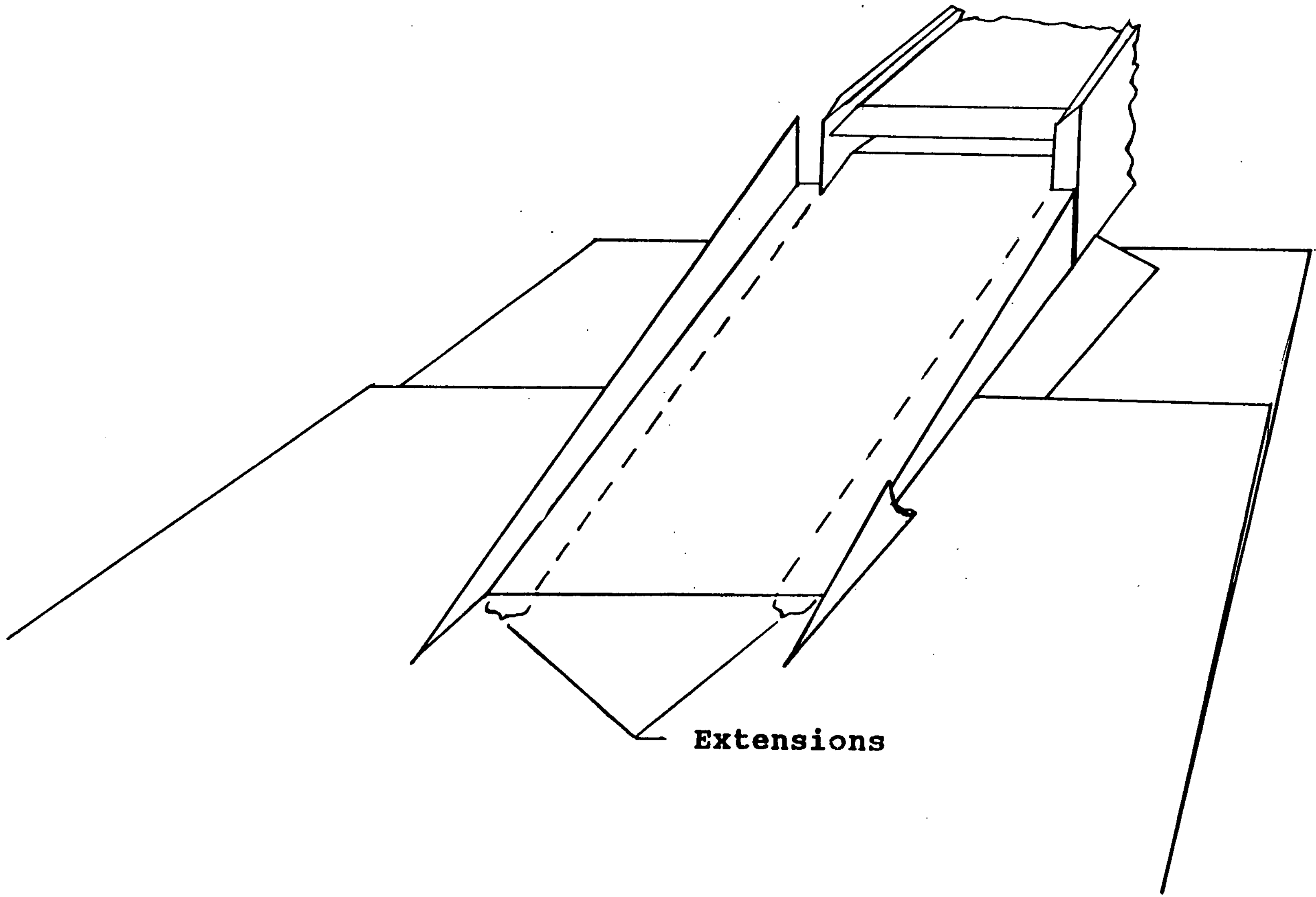


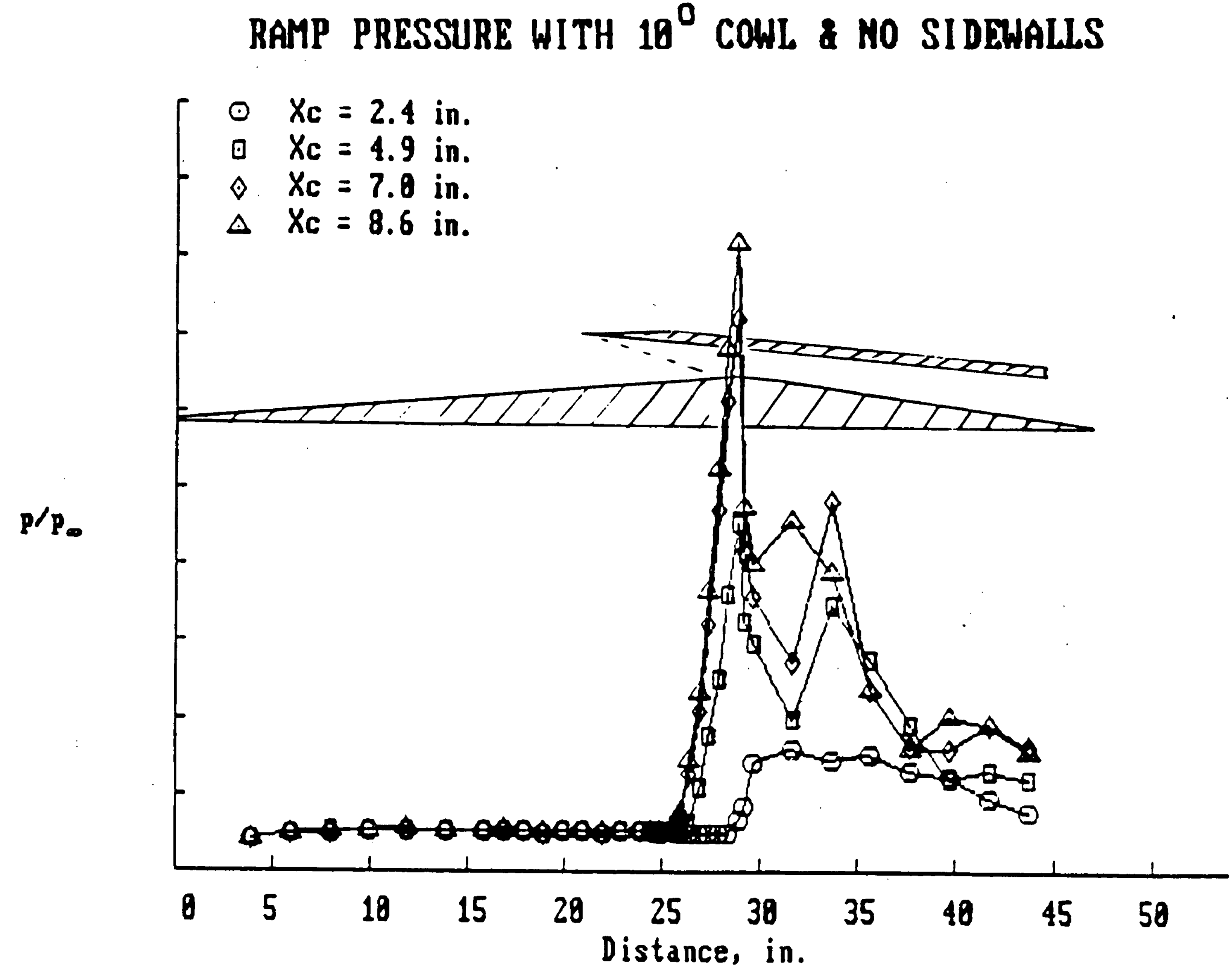
STATIC PRESSURE ON RAMP, 10° COWL (U)

Mach 18, P_T = 1200 psia



RAMP EXTENSIONS





RAMP PRESSURE WITH 10° COWL & NO SIDEWALLS
Xc = 2.4 in.
Xc = 4.9 in.
Xc = 7.0 in.
Xc = 8.6 in.
p/p∞
0
5
10
15
20
25
30
35
40
45
50
Distance, in.

CONCLUDING REMARKS

- Tests without a simulated forebody resulted in strong viscous interactions in the front portion of the inlet.

- With a simulated forebody, a more orderly inlet flow was noted, but still with significant bodyside viscous interactions.
  - Sidewall compression end effects on bodyside, sensitive to cowl location
  - 2-D inlet sidewall corner flow interaction with the cowl shock wave

- CFD analysis by Bill Rose and Ed Perkins tended to over predict viscous interactions

- Closer coordination with CFD community required to realize CFD code calibration aspects of high Mach number helium tests.